



# Source Apportionment and Multi-City/Multi-Pollutant Studies

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research  
and  
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## Background

Multi-city studies have been a corner stone of air pollution epidemiology for many years particularly in the study of regional exposure gradients of air pollutants from stationary sources and in the study of temporal gradients of air pollutants from a variety of sources

Epidemiologic findings from the Harvard Six-Cities Studies played an important role in the 1996 Air Quality Criteria Document for Particulate Matter and the 1997 National Ambient Air Quality Standard for fine particulate matter.

- The survival cohort study showed a strong association between regional sulfate exposure gradients and decreased survival
- The time-series mortality study showed that fine particles (< 2.5 mm) were more strongly associated with mortality than coarse-mode particles (2.5 to 10 mm).

## Major Multi-City Studies Since 1997

- The HEI-sponsored reanalysis of the American Cancer Society Survival Cohort.
- The EPRI-sponsored reanalysis of the Harvard Six-Cities Time-Series Study.
- The HEI-sponsored NMMAPS study of mortality provided information on the regional patterns of the association of mortality with inhalable particulate matter.
- The EPA-funded analysis of source apportioned particulate matter and mortality in the Harvard Six-Cities Time Series Study.

## Science Question

How can source apportionment and multi-city/multi-pollutant help to better characterize the effects of PM components?

## Rationale for Multi-City Studies

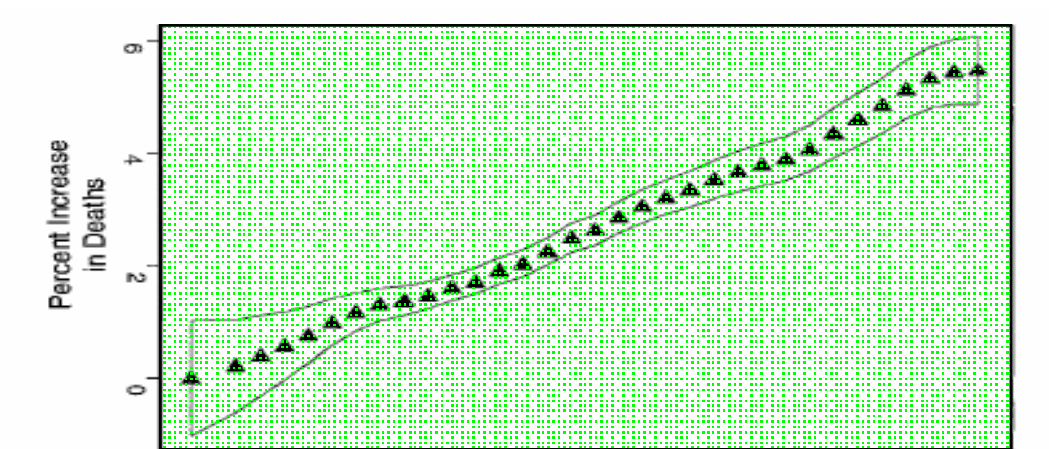
Multi-City studies have more precision due to the greater size of the study population permitting a more detailed examination of exposure-response relationships, coherence across health outcomes, and ability to examine potential confounding.

Multi-City studies also provide an opportunity to examine the adverse effects of particulate matter across cities with differing:

- levels of particulate matter
- levels of gaseous co-pollutants
- sources of particulate matter
- summer versus winter peaks
- prevalences of central air conditioning

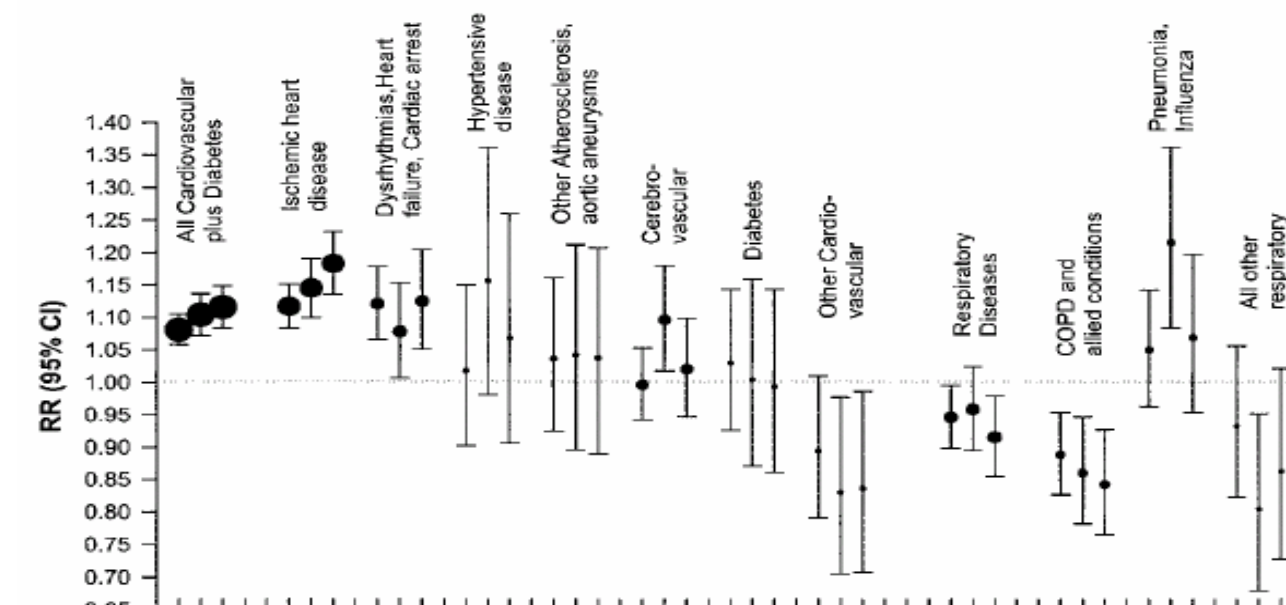
## Summary Across All Cities

Overall exposure-response curves can be more precisely evaluated in large multi-city studies.



Exposure-response between PM10 and daily deaths in ten U.S. cities.

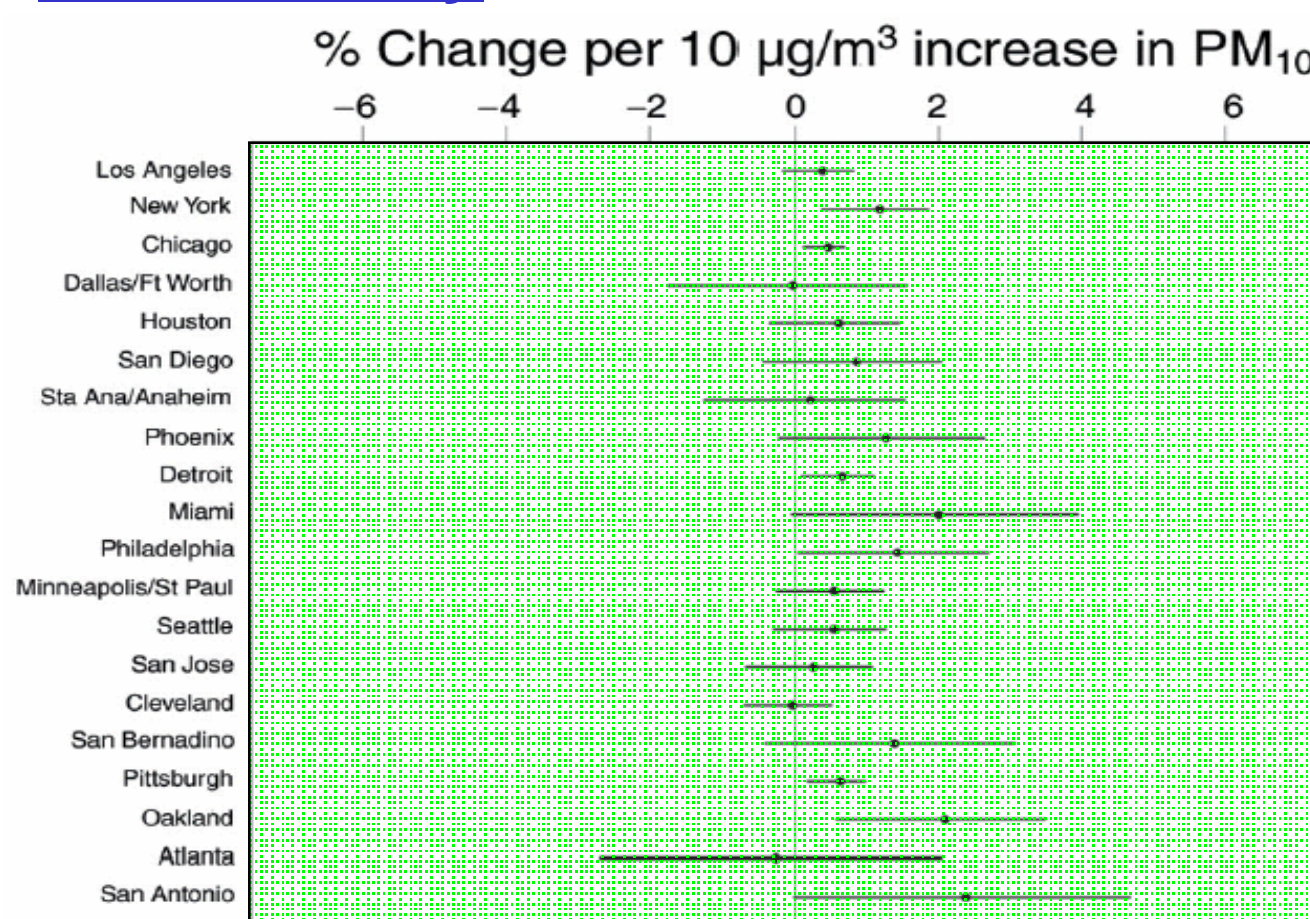
## Coherence Across Outcomes



Adjusted relative risk ratios and 95% confidence intervals for cardio-vascular and respiratory mortality associated with a 10 µg/m³ change in PM<sub>2.5</sub> for 1979 to 1983, 1999 to 2000, and average, respectively: American Cancer Society Cohort.

## Methods / Approach / Results

### Consistency Across Cities

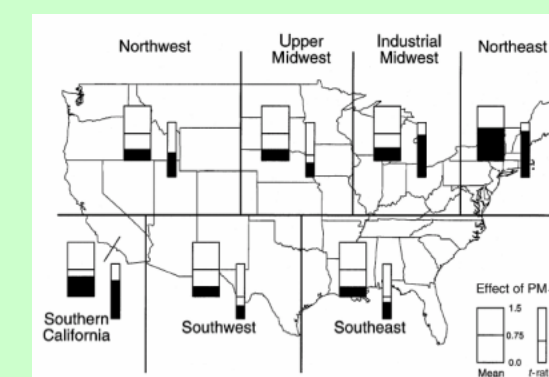


20 Largest U.S. Cities: NMMAPS mortality

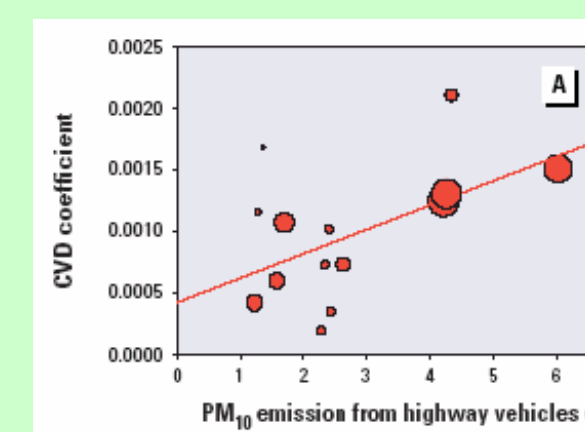
### City-to-City Heterogeneity

The NMMAPS studies also provided an opportunity for an examination of sources of heterogeneity in the effects of inhalable particulate matter (PM10).

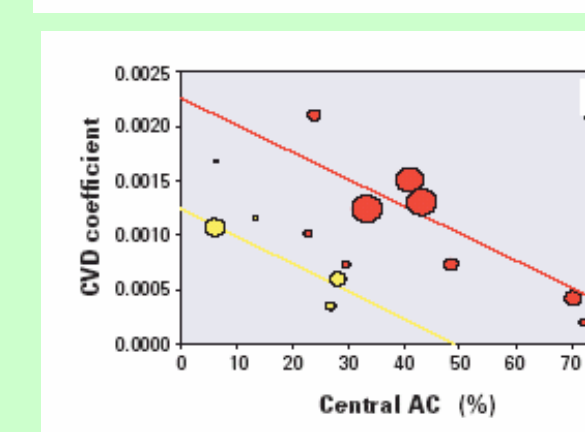
- Stronger associations with mortality in northeastern cities: a mean log-relative rate of 0.9 (95% CI 0.58, 1.31).



- Stronger associations with cardio-vascular hospitalization in cities with a higher proportion of particles from highway vehicles.



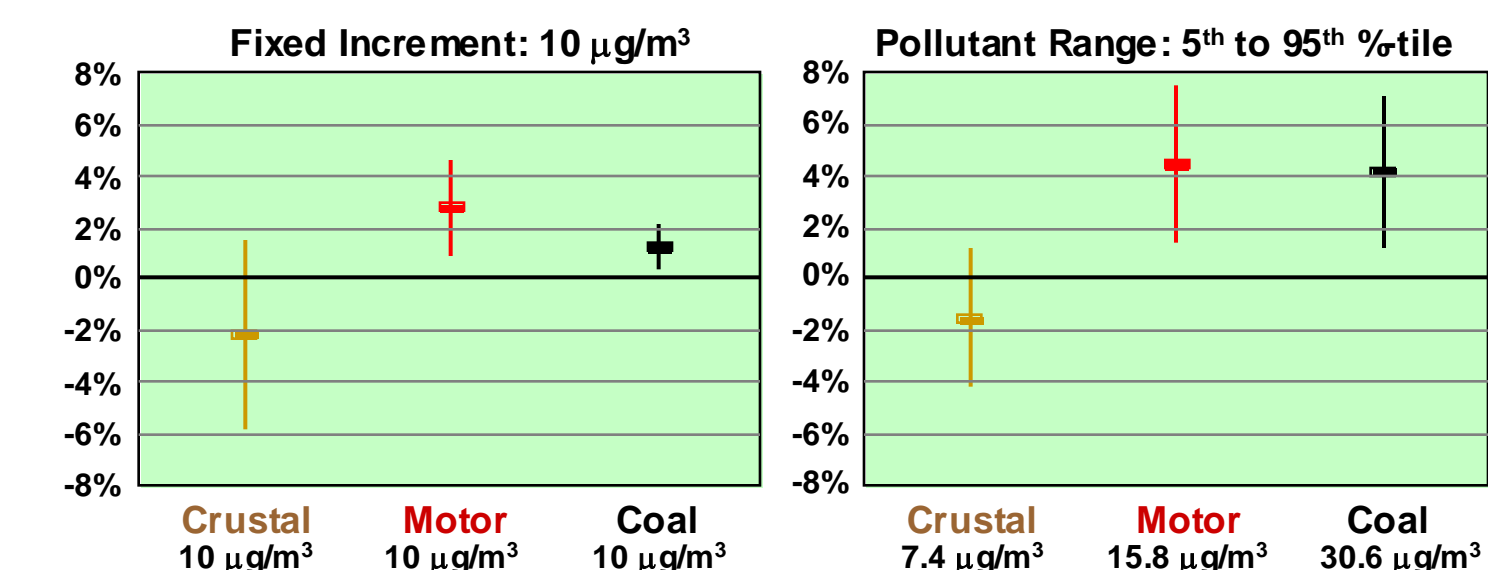
- Stronger associations with cardio-vascular hospitalization in cities with less central air conditioning and cities with non-winter peak particle concentrations (red).



### Source Apportionment

Source apportionment examines the heterogeneity of effects among particles from specific sources.

- Fine particles from mobile sources seem more strongly associated with mortality (per microgram) than fine particles from coal combustion.

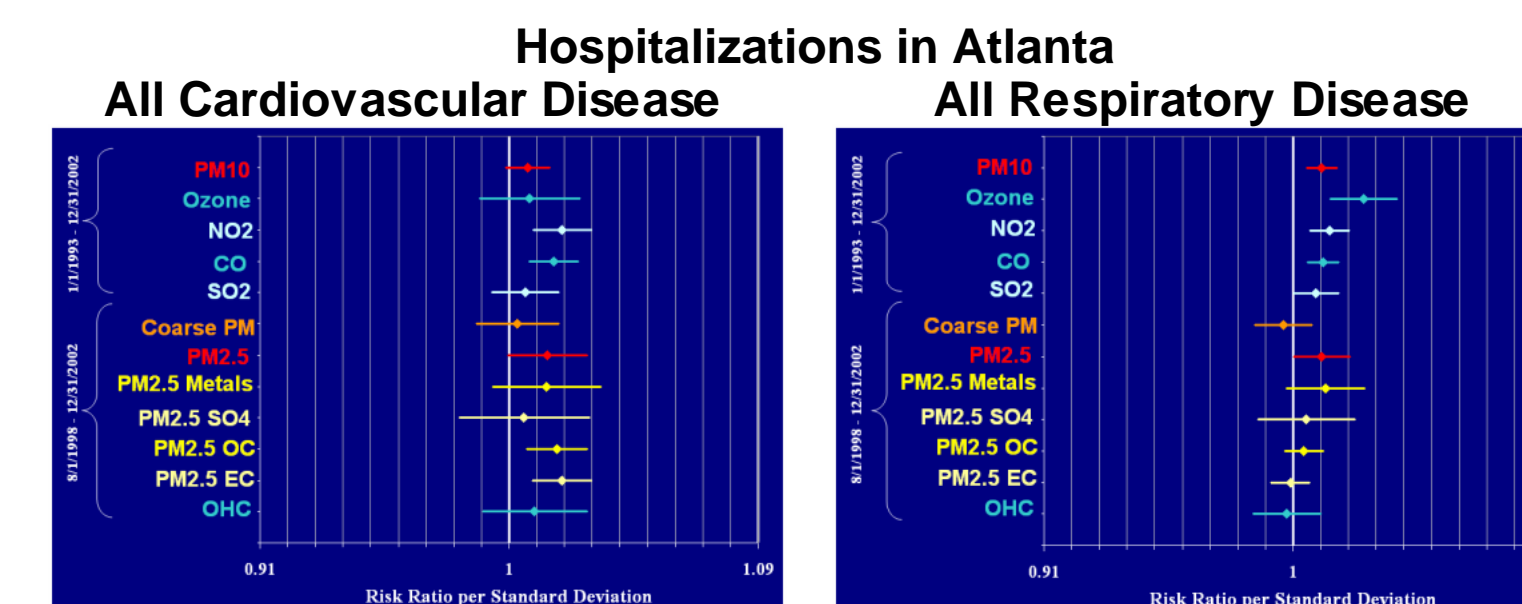


- However fine particles from mobile sources and coal combustion make similar contributions to mortality.

### Multi-Pollutant with Speciated Particles

Previous multi-city research was often limited to available compliance-oriented monitoring of criteria air pollutants. EPA has supported several enhanced monitoring efforts including the Supersite program.

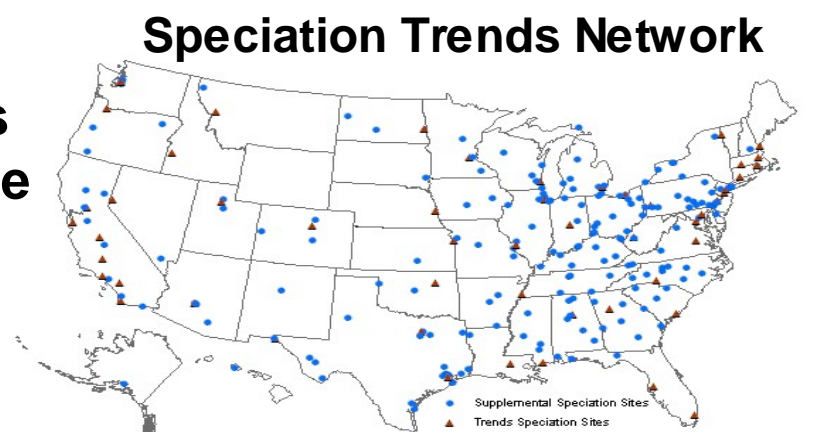
The improved availability of air quality data has facilitated research on speciated PM, including as the Aerosol Research Inhalation Epidemiology Study (ARIES) and Study of Particles and Health in Atlanta (SOPHIA).



Particulate-carbons (OC/EC) are more associated with cardiovascular admissions, while particulate-metals are more associated with respiratory admissions.

## Future Directions

The new national monitoring networks should provide future opportunities for further work of speciated particles.



Prior to the 2011 Air Quality Criteria Document for Particulate Matter, a new multi-city analysis should be conducted to address other areas of uncertainty in the science underlying the current standard.

- In a large study combining statistical power across many communities, what is the shape of the exposure-response relationship with fine and coarse-mode particulate matter, and does a threshold exist for health effects?
- What can city-to-city variations in the association of particles and mortality tell us about source-specific particle effects?
- What are the relative toxicities of particles from various sources as indicated by the association of source-apportioned particle exposures with the variation in daily mortality in multiple cities?

## Impact and Outcomes

Since 1997, multi-city, multi-pollutant studies have:

- confirmed associations between PM and mortality
- confirmed the exposure-response relationship
- examined coherence across health outcomes
- examined the consistency across cities and explanations for city-to-city heterogeneity
- examined the relative toxicity of different particles from various sources

These studies provide the OAR with important information about regional differences in health effects associated with PM, which may be derived from regional-specific sources.

# Source to Health Outcome